EXPERIMENTAL AND NUMERICAL INVESTIGATION OF FIBRE REINFORCED PLASTICS (FRP) STRUCTURE WITH BIO FILLERS

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ABSTRACT
Usage of polymer based, fiber reinforced composites (FRP) offers several advantages to achieve effective and reliable structures. The present study aimed to be the correlation of mechanical properties of composite structure (GFRP) with fillers under tensile load, impact load and water absorption environment. Fillers are added to the epoxy material (Matrix) with Glass fibre as reinforcement. The laminates would be fabricated using GFRP/epoxy filled with bio-filler (coconut coir) through compression moulding process. The results were calculated both experimentally and numerically under tensile and impact loading environment and for water absorption test it will be done experimentally. The numerical testing of the specimen was done by using commercially available software such as ANSYS. The final result indicates that the composite with bio fillers performs better than the conventional Glass/epoxy laminates.

KEYWORDS: *glass fibre, epoxy resin, bio fillers, coconut coir, composite structure.*

I. INTRODUCTION

The glass fibre is a composite material which is made of large number of fine fibres of glass. Usually the glass fibre is used as a strengthening in fabricating many products relating to polymers. The properties of glass fibre are greatly paralleled to the properties of carbon fibre and other fibre reinforced plastics because of its low-priced readiness and brittle in nature.

The glass fibre is of two types namely the E-glass fibre and S-2 glass fibre. By adding coconut coir at a suitable composition along with glass fibre and epoxy resin, the properties of resulting specimen can be upgraded in divergence to the normal glass fibre.

Two types of coconut coir are prevailing namely the brown fibre type and other one is white fibre type. The coconut coir we use in our project is the brown fibre type. Usually the husks of the brown fibre are saturated in a water body so that fibres become soft.

This paper targets to progress the mechanical properties of the specimen when exposed to tensile load, impact load and water absorbing environment by the combination of glass fibre along with the coconut coir. The epoxy resin acts as the matrix that binds the glass fibre and coconut coir to form the specimen without any air gaps that makes the specimen stiff and strong.

II. STRUCTURAL CONFIGURATION

A. Materials used

1. Glass fibre

The glass fibre type we have used in this paper is mat type belonging to the E- glass fibre. This glass fibre is made of large number of fine fibres of glass. Glass reinforced plastic is the resulting material we get by using this glass fibre.

2. *Epoxy resin and Hardener*

The use of epoxy resin is mainly to strengthen the durability of the specimen that is to be tested. Since epoxy resin has high adhesive strength it is widely chosen to act as a binding agent. Also epoxy acts a good resistance to heat, electrical and chemical environment. Epoxy is best selected as a matrix because of good wetting property.

3. *Coconut coir*

Coconut coir is a natural fibre that is mined from the shell of coconut. Coconut coir is commonly known as coconut fibre. Generally coconut coir is of two types namely brown fibre and white fibre. Since the brown fibre has an advantage of not sinking, it is used along with glass fibre for water absorption testing.

B. *Specimen Geometry*

In this paper we are mainly focussed on the structure of the rectangular composite plate. Since three testing's has been performed, three specimen of different dimensions as per the ASTM standards are used for the respective tests

C. *Rule of mixture*

	Glass fibre	Epoxy resin	BIO FILLERS
SPECIMEN 1	30%	60%	10%
SPECIMEN 2	40%	50%	10%
SPECIMEN 3	60%	30%	10%

By using this rule of mixture the specimen is fabricated by compression moulding process at a pressure of 500 KPa and 35 °C for the specimen size of,

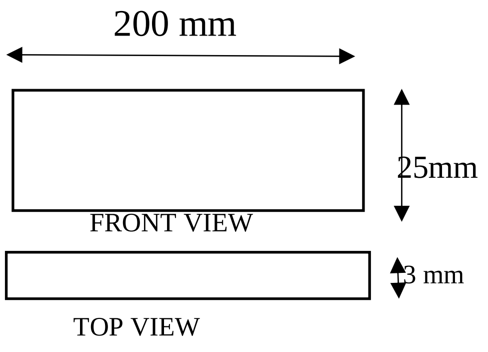
Length = 290 mm
Width = 290 mm
Thickness = 3 mm

III. EXPERIMENTS

A. *Tensile test*

Tensile test also commonly known as tension testing is a generally used test in engineering in which a specimen is exposed to a controlled tension or load until failure. The standard for tensile test is ASTM D3039 and the specimen is cut to the dimensions respective to this standard. Generally this test is carried out to determine the ultimate tensile strength and displacement of the specimen directly under tension.

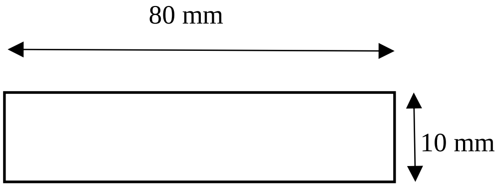
Dimensions of tensile test specimen as per ASTM D3039



B. Impact test

Impact test also known as Charpy impact test is carried out to dictate the energy absorbed by the testing specimen during the time of fracture. The standard for Charpy impact test is ASTM E23 and the specimen is cut to the dimensions respective to this standard. Also by carrying this test, the ductility of the sample specimen can also found ÷qualitatively.

1. *Dimensions of impact test specimen as per* ASTM E23



FRONT VIEW

TOP VIEW

C. Water absorption test

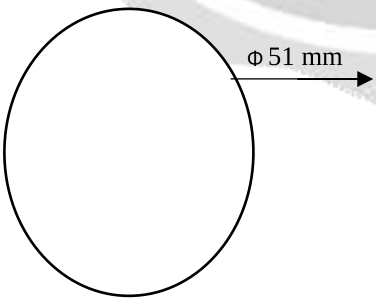
Water absorption test is carried out to dictate the substantial of water absorbed by the sample specimens under fixed conditions. In this test the sample specimens are dried out in a muffle furnace for a particular temperature and time in order to eliminate the moisture content from the specimen. The specimen are dipped in beakers containing water, distilled water and salt water for 2 hours and 24 hours respectively. Finally the specimens are taken out from the beaker and the water from their surface are scrubbed using cloth and then they are weighed to find the amount of water absorbed by them.

The formula to find out the rate of water absorbed by the specimen is,

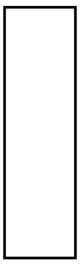
$$M\,\% = \frac{m_o - m_i}{m_i}$$

where m_o = final mass (g)
m_i = initial mass (g)
M % = percentage of water absorption

1. *Dimensions of water absorption test specimen as per* ASTM D570



FRONT VIEW



IV. FINITE ELEMENT ANALYSIS

A. Applications of ANSYS- FEA

The computerized method of foreseeing the responses of product to forces, vibration, heat and flow of fluid is called as finite element analysis. The finite element analysis helps in predicting the products behaviour that are affected by many physical effects that includes

- Mechanical stress
- Mechanical vibration
- Fatigue
- Motion
- Electrostatics

V. RESULTS & DISCUSSIONS

A. Tensile test

Test parameters	Observed values		
Sample ID	Id-1	Id-2	Id-3
Gauge length (mm)	190	195	200
Gauge width (mm)	20	23	25
Gauge thickness (mm)	3	3	3
Ultimate tensile load (KN)	11.63	13.14	14.68
Ultimate tensile strength (MPa)	159	176	170

B. Impact test

Sample ID	Absorbed energy (Joules)
ID -1	6
ID -2	3
ID- 3	2

C. Water absorption test

1. Distilled water

Time (hours)	m_i (g)	m_0 (g)	Difference (g)	%
2 hours	9.37	9.41	0.04	0.0042
24hours	9.45	9.54	0.09	0.0095

2. Water

Time (hours	m_i (g)	m_o (g)	Difference (g)	%
2 hours	9.35	9.37	0.02	0.0021
24hours	9.49	9.56	0.07	0.0073

3. Salt water

Time (hours	m_i (g)	m_o (g)	Difference (g)	%
2 hours	9.40	9.43	0.03	0.0031
24hours	9.68	9.78	0.10	0.0103

D. FINITE ELEMENT ANALYSIS RESULTS- TENSILE TEST

1. AT LOAD 11.63KN

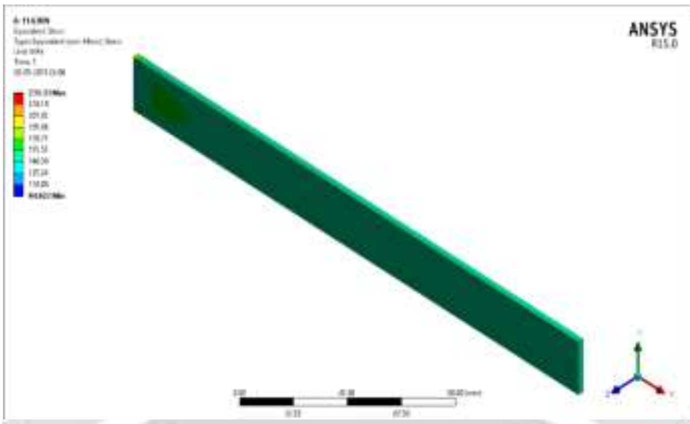


Fig 5.1 stress acting on specimen at 11.63 KN

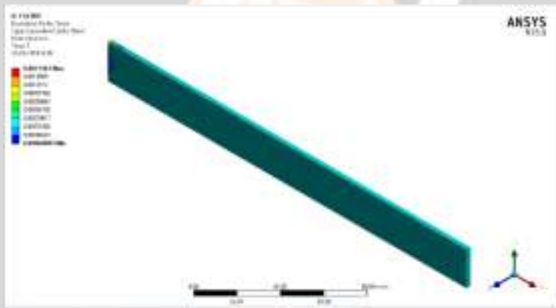


Fig 5.2 Strain acting on specimen at 11.63KN

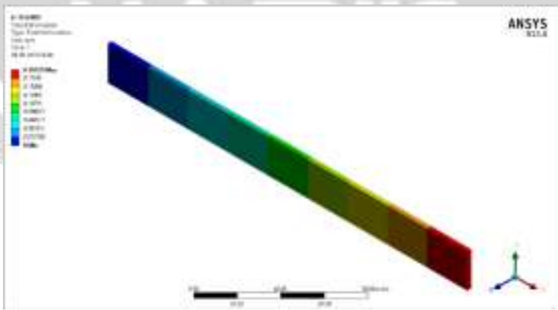


Fig 5.3 Deformation of specimen at 11.63 KN

2. AT LOAD 13.14 KN

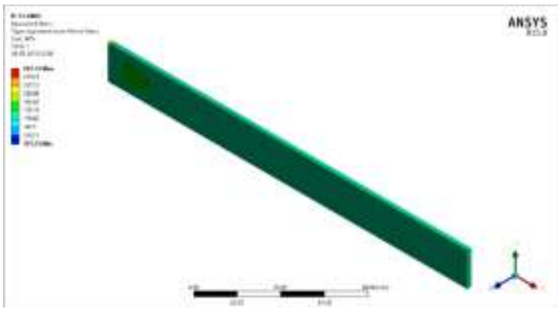


Fig 5.4 Stress acting on specimen at 13.14 KN

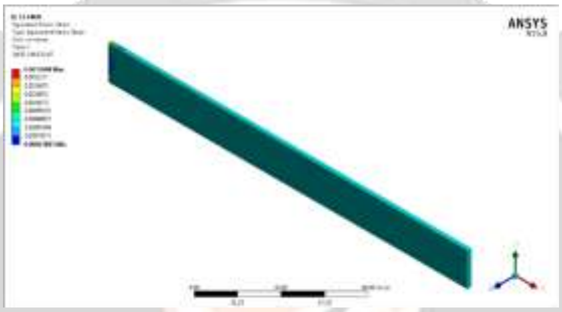


Fig 5.5 strain acting on specimen at 13.14 KN

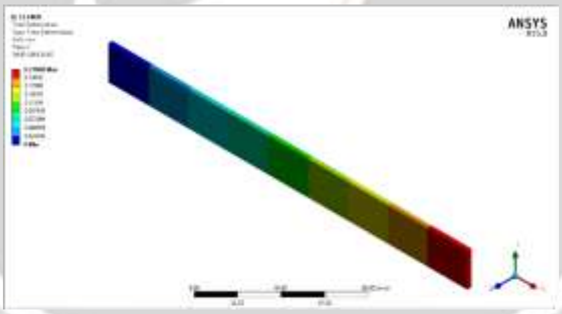


Fig 5.6 Deformation of specimen at 13.14 KN

3. AT LOAD 14.68 KN

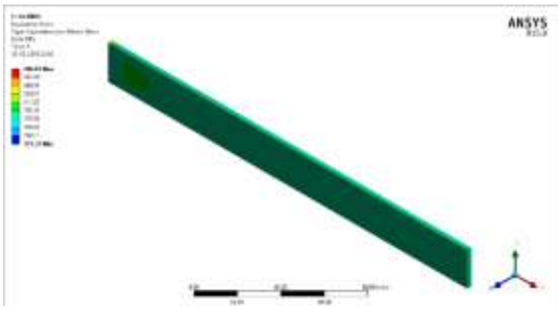


Fig 5.7 Stress acting on specimen at 14.68 KN

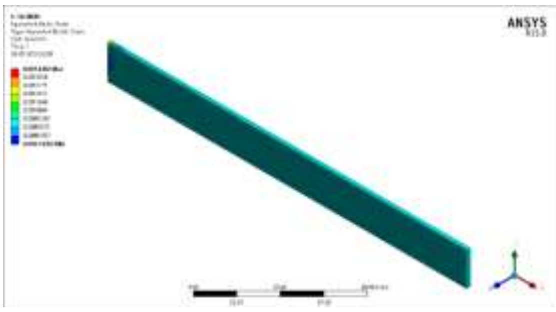


Fig 5.8 Strain acting on specimen at 14.68 KN

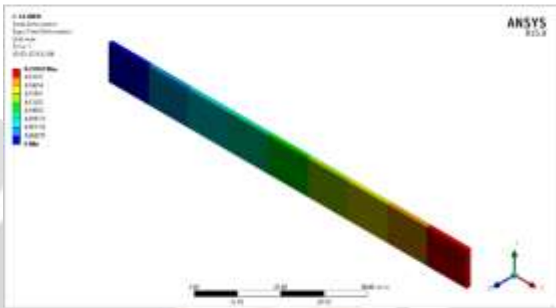


Fig 5.9 Deformation of specimen at 14.68 KN

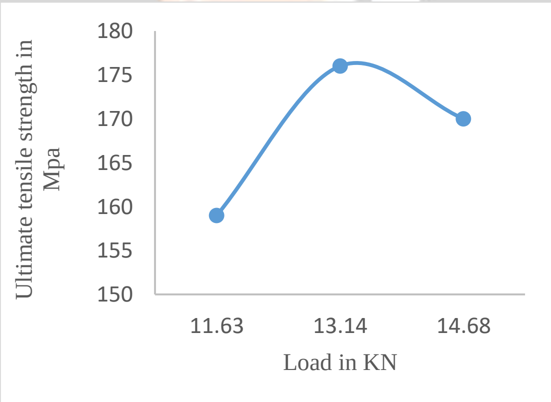


Fig 5.10 Load vs ultimate tensile strength for tensile test

IMPACT TEST ANALYSIS RESULTS

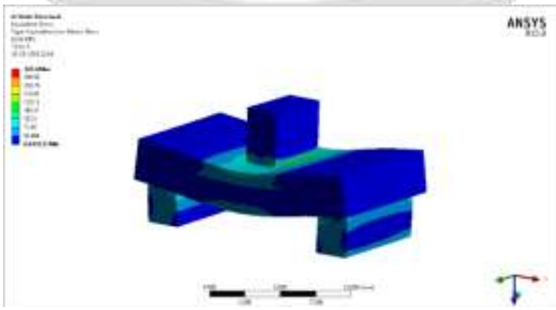


Fig 5.11 Equivalent stress acting on specimen

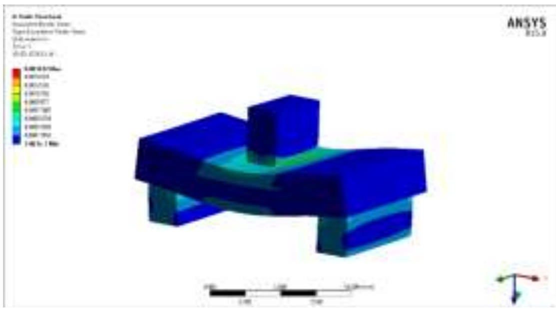


Fig 5.12 Equivalent strain acting on specimen

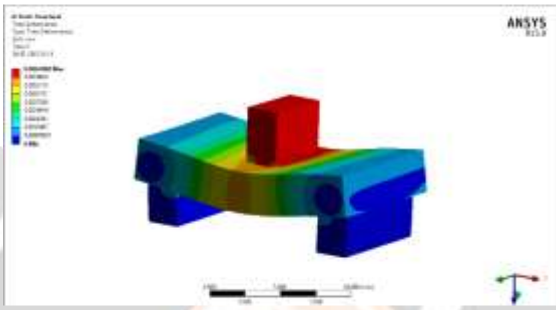


Fig 5.13 Total deformation of specimen

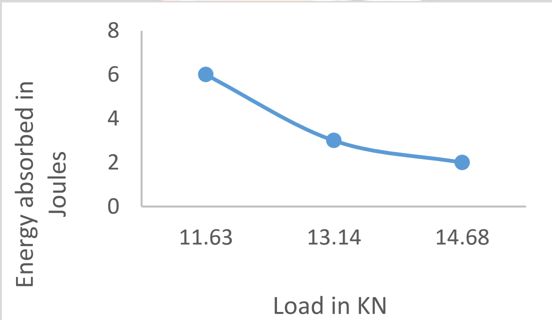


Fig 5.14 Load vs Energy absorbed in Joules for impact test

A. Results correlation

The composite enclosing glass fibre, epoxy resin and coconut coir has been premeditated in detail. The finite element analysis has been carried out using ANSYS software to correlate the arithmetic results with that of the experimental results. The graphs for tensile test of ultimate load versus ultimate tensile strength and for impact test of load versus energy absorbed is plotted. The tensile test graph specifies that the ultimate tensile strength rises up to 13.14 KN and reaches fracture above this point. The graph plotted for impact test shows that energy absorption attains the minimum value at 13.14 KN and again starts increasing above this point.

Based on the correlation results, it is found that the glass fibre containing bio fillers executes better than normal composites.

VI. CONCLUSION

The experimental results were correlated with the numerical results performance in Fe simulation (ANSYS) and experiments shows that composite with bio filler (coconut coir) resists high load and high energy absorption than that of normal composites.

Water absorption test has also been executed and the rate of water absorbed by the specimen respective to different water environment is calculated. The result shows clearly that glass with bio fillers composite specimens absorb less water than the other composites specimen under three different water environment (water, salt water & distilled water).

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